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Sizing of Solar PV Power Plant in Stand-Alone Operation

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Abstract--The objective of this paper is to sizing the solar power plant in standalone mode of operation. Based on the load survey and the utilization factor, the capacity of the plant is determined for battery sizing and PV sizing. PVSYST and C programming are used for the sizing of the solar PV power plant. A survey is also conducted about the requirement of customers regarding the solar power plant. Sri Ramakrishna Institute of Technology (SRIT) hostel mess is considered in this paper for the purpose of load survey and sizing of the solar power plant. The installation of solar PV power plant in SRIT hostel mess based on the design features developed in this work will ensure reliability of power supply to the hostel mess for preparation of food without any interruption. Future, the burden on the electrical network also will reduce to a large extent. This paper will be useful for the design and installation of PV power plant in a location suitable for such an operation replacing/supporting the conventional source.

***Key Words*--battery sizing, PV sizing, PVSYST**

I.INTRODUCTION

Today energy crisis is more all over the world. The coming era of limited and expensive energy will be very difficult for everyone on earth but it will be even more difficult if it is not anticipated. It is of utmost importance that the public and especially policymakers understand the global energy crisis and the underlying science.

Renewable energy sources occur in nature which are regenerative or in exhaustible like solar energy, wind energy, hydro power and geothermal. Most of these alternative sources are the manifestation of solar energy. Renewable sources contribute to about 12% of the total power generating capacity in the country. Motivation for the renewable energy sources are increasing scarcity and price of fuels, environmental and health consequences of large-scale fuel consumption, foreign trade deficit, vulnerability of imported fuel supply and maintenance of nuclear power plants [1]. Solar energy is the cleanest and inexhaustible of all known energy sources. Solar radiation holds huge amounts of energy and is responsible for almost all the natural processes on earth.

The aim of paper is to reduce the power demand using solar energy. Today people are facing power cut for more hours in Tamil Nadu because of power demand. The power can be saved by installing solar plant in industries, houses and colleges. The solar power plant was designed for all loads using software and civil structuring for plant set up. The model chosen for this project is SRIT Hostel Mess to overcome the usage of high rating generator for low load hostel mess applications. By installing solar power plant the power demand can be minimized to the maximum extent.

In this paper the load survey for both boys and girls hostel mess were done and based on the load survey the manual calculation of battery sizing and PV sizing are calculated. The project deals with PVSYST software for calculating Battery Sizing and PV sizing. Simulation parameters for both Boys and Girls hostel for Grid connected and Stand-alone application. Using C program the Battery sizing, PV sizing, number of PV modules are calculated. The civil structure was designed with the accessories needed for it.

The designing of the layout for Boys hostel and Girls hostel are done using PHP language. Here based on the number of panels, panel width and panel height the output and layout for both hostels were obtained. Civil structure is also calculated for the project, in which Load calculation for the solar power plant is calculated and Accessories needed for the project are given.

Civil structure is followed by solar power plant market survey. In this the consumer requirement analysis, site survey and feasibility assessment were given and market survey for 10kw and 60kw solar power plant were provided for consumer requirement. The output will be tested with 60kw plant Grid connected system foe SRIT College which is 20% of the total load of SRIT College [2]-[5].

II. SOLAR PV SYSTEM

There are two types of PV systems
A. Grid connected system
B. Stand-alone system

A. Grid Connected System

Grid connected system refers to a solar panel electrical system which is connected to the mains power grid, so any excess power it generates can be fed back into the mains power grid. In a grid connected system, the grid acts as a back-up and there is no need for battery storage unless there is a power outage problem. This makes grid connected PV systems relatively simple. However, PV systems have to compete with cheap grid supply which make it hard to

justify the system unless some kinds of subsides are provided.

Grid-connected system is connected to the utility grid with two metering system. It may be a small roof top system owned and operated by the house owner or a relatively bigger system, meant for the whole village. It meets day time requirements without any battery and surplus power is fed to the grid. During peak hours and during nights, the energy shortage may be met from grid [6]-[7].

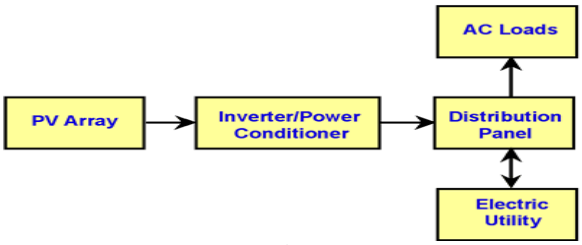


Fig.1. Layout of a Grid connected system

B.Stand Alone System

A stand-alone power system (SAPS or SPS), also known as remote area power supply (RAPS), is an off-the grid electricity system for locations that are not fitted with an electricity distribution system. For stand-alone systems with battery storage charge controllers, inverters are important components apart from solar panel and battery [8]-[9].

Stand alone system is directly connected to the load. Excess power will be stored in battery for future purpose when there is demand for power during non sun period. No grid is connected to this system, thus working on its own. The steps to be carried out for installing Stand-alone system given as follows

- Defining the user needs.
- Selecting the model for the PV module and a compatible battery set model according to the user needs.
- Deciding the regulator for the system.
- Determining the tolerable fraction of losses.

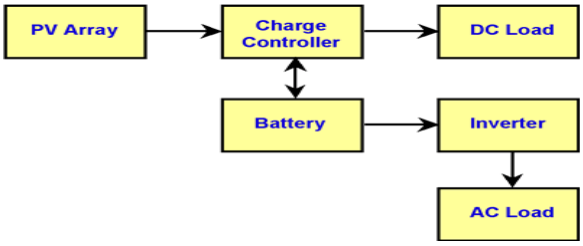


Fig.2. Layout of a Stand-alone system

III. LOAD SURVEY

A Load Survey is an inspection, survey and analysis of energy flows for energy conservation in a building, process or system. A Load Survey is a preliminary activity towards instituting energy efficiency programs in an establishment. It consists of activities that seek to identify conservation opportunities preliminary to the development of an energy savings program.

Important Points to Consider When Collecting Site Load Data

a. Operating hours - This can be gathered from plant personnel. It is important to ensure the accuracy of this data because much of the potential for energy savings lies on correct estimation of the equipment's operating hours.

b. Duty cycle - Machines such as large electric motors have varying loads and hence, different power requirements.

c. Actual power consumed - For electric power users, this is based on either 3-phase current/voltage readings or power analyzer measurements (e.g., direct kW which incorporates power factor). For fuel users, tank readings of monthly consumption estimates and flow meters with totalization can be sources of measurement.

TABLE I. Load Survey for Boys Hostel Mess

Types of Load	Rated Power (Watt)	No. of Loads	Total Rated Power (Watt)	Hours of Use	Total Energy Consumption (Watt-Hour)
Atta kneading machine	1492	1	1492	2	2984
Lighting	40	18	720	8	5760
Exhaust fan	350	1	350	6	2100
Grinder	746	2	1492	2	2984
Salt water pump set	5968	1	5968	3	17,904
soft water pump set	1492	1	1492	3	4476
Fridge	600	1	600	24	14,400
Vegetable cutter	207	1	207	2	414
Blower	1701	1	1701	6	10,206
Deep freeze	207	1	207	24	4968
			14,229		**66,196**

TABLE II. Load Survey for Boys Hostel Mess

Types of Load	Rated Power (Watt)	No. of Loads	Total Rated Power (Watt)	Hours of Use	Total Energy Consumption (Watt-Hour)
Atta kneading machine	1492	1	1492	2	2984
Lighting	40	17	680	8	5440
Exhaust fan	350	3	1050	6	6300
Grinder	746	3	2238	2	4476
Salt water pump set	3730	1	3730	3	11,190
Soft water pump set	1492	1	1492	3	4476
Fridge	600	1	600	24	14,400
Vegetable cutter	207	1	207	2	414
Deep freeze	207	1	207	24	4968
			11,696		**54,648**

The load survey for SRIT Girls and Boys hostel mess were done. The details such as type of load, rated power in watts, number of loads, total rated power in watts, hours of use and total energy consumption for each load are collected and average power calculated for both hostel mess considering an utility factor of 0.7.

In the boys hostel mess the total load is **14 kW.** The total energy consumption is **66.196kW-hour.** Considering the utilization factor 0.7, the effective load is 9.8kW. In the girls hostel mess the total load is **11kW.** The total energy consumption is **54.648kW-hour.** Considering the utilization factor is 0.7 and the effective load is 7.7 kW

IV. SIZING FORMULAES

A. Formulae for Calculation

1) Battery Sizing

a. Required Supply Wh = Load Wh * (No.of day of storage + 1)

Include Efficiency factor from name plate of battery Depth of Discharge (DOD) Battery efficiency factor (BEF) System

b. AC efficiency (ACEF) {ACEF = Inverter Efficiency x AC Cable Loss Factor}

c. Battery Wh = Supply Wh / (DOD*BEF*ACEF)

Select Battery Voltage (VBAT) based on system voltage. For Small systems (<1kWh) 12VDC, mid-range systems (1-3kWh) 24VDC, larger systems (>3kWh) > =48 VDC can be used.

d. Battery Ah = Battery Wh/VBAT Select nearest larger rating available.

2) Battery Pack

Check available Battery unit voltage and Ah. Select Battery unit Ah such that Battery Pack Ah requirement is either met or exceeded with number of Battery units in parallel

No. of Battery units in parallel = Battery Pack Ah / Battery Unit Ah Battery

Peak voltage is integral multiple of Battery unit voltage

No. of Battery units in series = Battery Pack Voltage/Battery unit voltage

Example of battery selection –

1. Standard deep cycle lead acid battery voltage rating available is 12V
2. Standard battery Ah available is 120Ah, 150Ah, 180Ah etc. Example: 24V/350Ah Battery Pack.

3) PV Sizing

a. Load Wh = Daily energy requirements

b. Average daily peak sun hours (PSH) in design month for selected tilt and orientation of PV array.

c. System Efficiency Factor (SYSEF) SYSEF = DCEF x BEF x ACEF

Where DCEF = PV Loss Factor x DC Cable Loss Factor x Charger Efficiency

d. PV Watts peak (Total Wp)= Load Wh/(PSH*SYSEF)

e. Select PV module voltage based on system voltage. (System voltage is integral multiple of PV module voltage)

f. Select module Wp and size based on available space.

g. No. of PV Modules = Total Wp/Module Wp

Use nearest larger number of modules from number calculated of modules required [10].

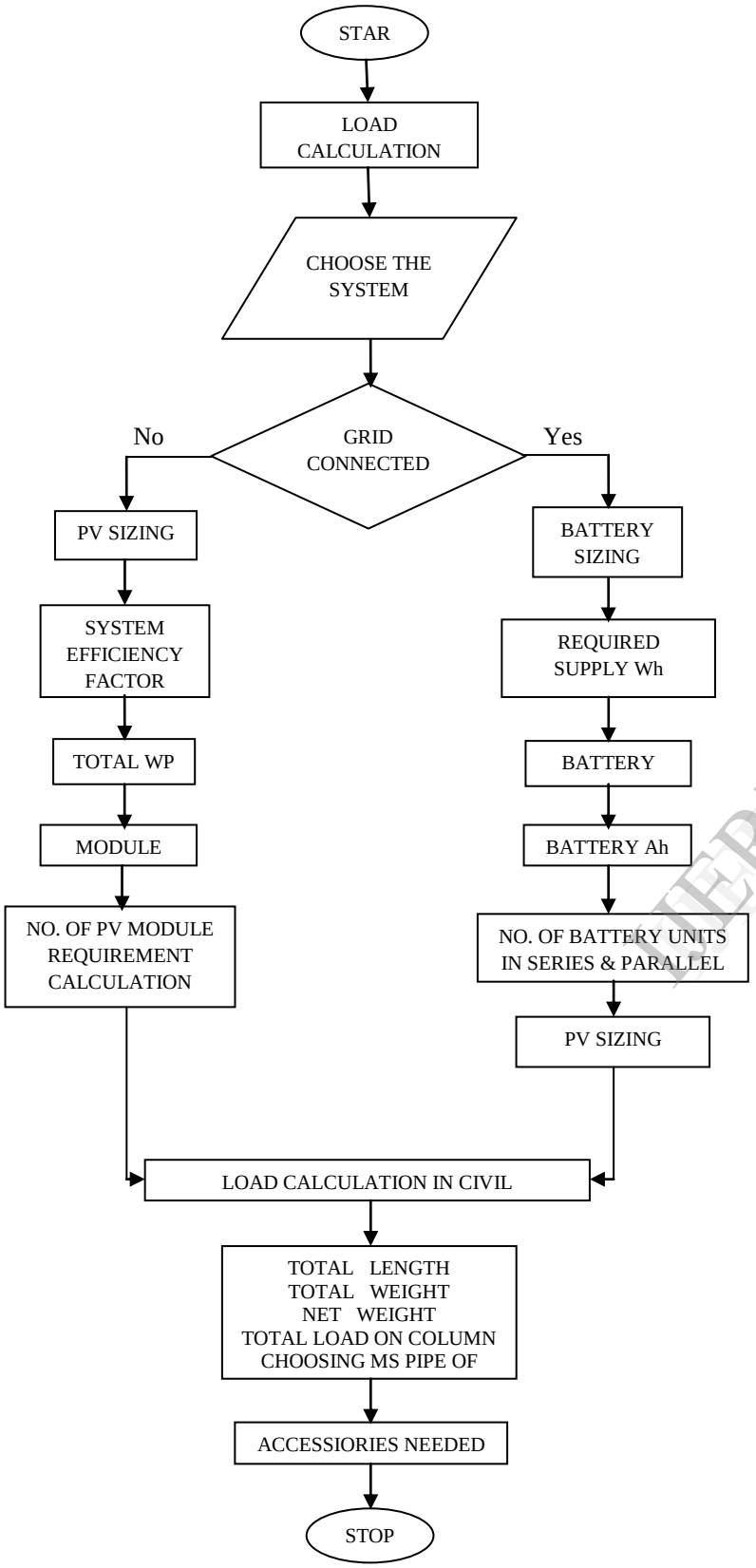
V. SOFTWARE DESCRIPTION

A. General Description of the PVSYST Software

PVSYST V5.0 is a PC software package for the study, sizing and data analysis of complete PV systems. It deals with grid-connected, stand-alone, pumping and DC-grid PV systems, and includes Extensive meteorological and PV systems components databases, as well as general solar energy tools. This software is geared to the needs of architects, engineers, researchers. It is also very helpful for educational training. PVSYST V5.6 offers 3 levels of PV system study, roughly corresponding to the different stages in the development of real project.

B. Using C Program

C program has been written to calculate the total energy consumption of each type of load, total energy consumption of system, total weight of the solar plant structure, structural dimension of plant for standalone and grid connected configuration for both boys and girls hostel. This generalized source code can be used for any other system which consists of number of electrical load.



VI. CIVIL STRUCTURE

Civil structure is designed for the set up of solar plant in the hostel location. It can be designed based on the number of panels used, weight and size of the panel. It demonstrates the total weight, total length, angle of size and MS pipe of size. The civil structure gives the details of accessories needed.

A. Load Calculation for the Solar Power Plant

Length of panel in mm= 1512
Width of panel in mm= 50
Total no of panels in mm= 48
Spacing of grids:
In horizontal direction in m= 1.5
In vertical direction in m= 1
Weight of the panel in kg= 22
Choose the column:
Number of horizontal member= 6
Length of horizontal member in m= 1.5
Number of vertical number= 2
Length of vertical member in m= 5
Total length in m = [(Number of horizontal member* Length of horizontal member) + (Number of vertical member*Length of vertical member)]
= [6*1.5+2*5]
=19
Choose angle of size from steel table:

1. (50*50*4)mm=3kg
2. (50*50*6)mm=4.5kg
3. (55*55*8)mm=8.18kg
4. (55*55*10)mm=10.02kg
5. (75*75*4)mm=5.7kg
6. (100*100*6)mm=9.2kg

Total weight in kg=Length*weight of MS angle
=19*3
=57
Assume self weight of column in kg =10% of total weight
=5.7
Net weight in kg =Total weight + self weight of column
=57+5.7
=62.7
Weight of solar panel in kg=22
Weight of MS angle in kg= 3
Total load on column in kg= Weight of solar panel+ Weight of MS angle
=22+3
=25
Choose MS pipe of size

1. 50mm
2. 75mm
3. 100mm
4. 125mm
5. 150mm

B. Accessories Needed

1. ACDB-Alternative Current Distribution Board
2. DCDB-Direct Current Distribution Board
3. Lightning Arrestor with Earthing conductor

It is a device used on electrical power systems and telecommunication systems to protect the insulation and conductors of the system from the damaging effects of lighting.

4. Junction box
5. Earthing conductor

It is a kind of lighting protector which avoids lighting punctures on cables.

VII. SOLAR POWER PLANT-MARKET SURVEY

A. Customer Requirement Analysis

1. Assessment of user requirements, cost, time scale and space constraints
2. Provide power to day time loads
3. Provide power to night time loads
4. Provide power 24x7 to critical loads
5. Battery Autonomy
6. Share power with other RE sources
7. Seasonal load requirements
8. Future expansion
9. Availability and quality of grid
10. Share power with grid or DG

B. Site Survey and Feasibility Assessment

1. Latitude, Longitude of the site
2. Location, shape, size and level of roof/terrace
3. Terrace/roof orientation and tilt
4. Shadow analysis
5. Static load bearing
6. Capacity of the roof/terrace
7. Height of parapet wall
8. Cable duct availability
9. Electrical distribution location and diagram
10. 1ph/3ph load
11. Load energy metering
12. Control room location and size
13. Access to roof/terrace
14. Architectural and regulatory requirements

VIII. CONCLUSION

SRIT hostel mess was considered in this project for the purpose of load survey and sizing of the solar PV power plant. Based on the load survey and the utilization factor, the capacity of the plant was determined for battery sizing and PV sizing. PVSYST and C programming were used for the design of the solar PV power plant. A survey was also conducted about the requirement of customers regarding the solar power plant. The software developed was calculated for SRIT hostel mess and tested for 20% of total load in SRIT College i.e. 60KW and the output were verified. This project will help the electrical utility to design their power plant with solar energy in an efficient manner. The software developed will provide an opportunity to the vendors to convince the customers for installing solar power plant in their institution/industry as the design of the plant can be shown for any capacity within a short period of time.

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